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3.17 SIMOLINK drive coupling

3.17.1 Basic information

Introduction

SIMOLINK (**Si**emens **Mo**tion **Link**, SL) is a digital, serial data transfer protocol using fiber-optic cables as data transfer medium.

The SIMOLINK drive coupling has been developed for extremely fast and/or rigid cycle transfer of process data (setpoints, actual values, control and status information)

- between drives (dispatcher, transceiver)
  - SIMOVERT MASTERDRIVES MC/VC, or
  - SIMOREG DC-MASTER or
- between drives and a higher-level automation system (SL master)
  - SIMATIC S7-400 station with FM 458 and EXM448-1 or
  - SIMADYN D subrack with PM5/6 and ITSL
- between automation systems (SL master, slave/s)

Where all of the connected nodes are synchronized (SYNC telegram) to a common system clock.

Application

By transferring a time-equidistant and jitter-free SYNC telegram, SIMOLINK allows high-dynamic response and all of the connected individual drives move in absolute position synchronism (e.g. virtual shaft).

Features

- Max. 201 active nodes (SL master, dispatcher and transceiver, passive nodes include switches and cable concentrators)
- Bus cycle:
  Time between two SYNC telegrams, i.e. the circulating time in the ringbus
- SYNC telegram:
  All of the connected nodes are synchronized after the telegrams were sent
- Telegram:
  32-bit word (double word), occupies one channel for each piece of process data.
- Nodes read **and** write their data once every bus cycle.

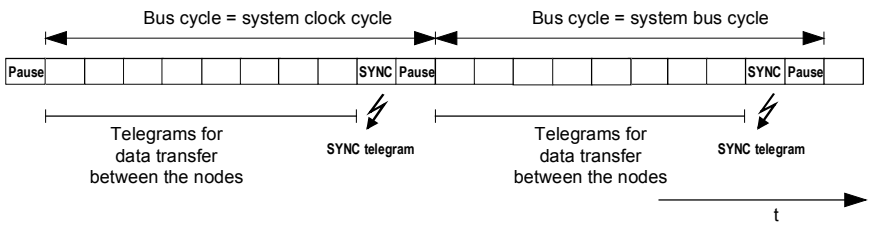

Fig. 3-51 SIMOLINK telegram data transfer

- Telegram runtime: $6.\overline{36}\ \mu s$
- All of the telegrams are sent immediately one after the other.
- For instance, for a selected bus cycle time of 0.8 ms, the SL master can transfer

  – one double word each to a max. of 124 slaves/transceiver, or
  – 4 double words each to a max. of 31 slaves/transceiver

  The remaining times are intervals where a telegram is not sent (NOP).
- Master-slave process data transfer:

  – up to 200 slaves/transceiver can be addressed with address gaps
  – up to 8 double words individually for each slave/transceiver
  – own process data for each slave/transceiver
- Dispatcher transceiver process data transfer:

  – up to 200 consecutively addressed transceivers
  – up to 8 double words
  – the same number of used channels for dispatcher and transceiver (nodes with a max. number of double words defines the number of channels for all)
- Data transfer rate: 11 Mbit/s
- Bus topology: Fiber-optic cable ring, each node as signal amplifier
- Max. distance between two nodes:

  – 40 m for plastic fiber-optic cables, or
  – 300 m for glass fiber-optic cables.

3.17.2 Application with master-slave process data transfer

The automation system with SIMOLINK interface is generally configured as the SL master. Whereby, all of the other coupling nodes are set as slaves/transceiver (refer to MASTERDRIVES option module SLB SIMOLINK).

The number of channels used for each slave/transceiver is defined by the SIMOLINK function blocks (connections CTV, CSV).

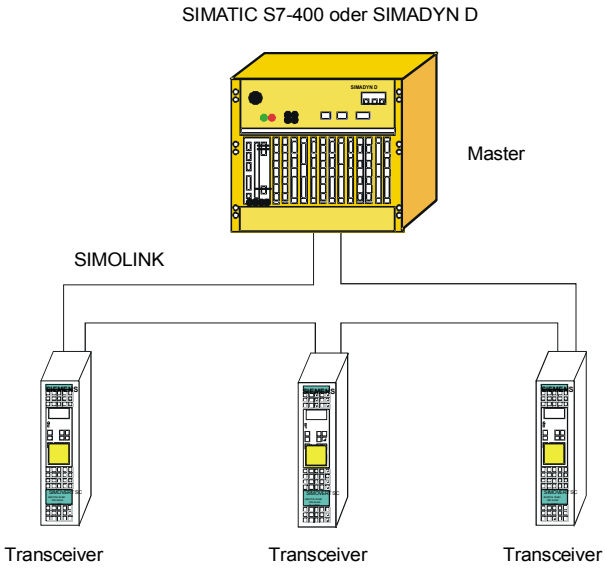

Fig. 3-52 Application example for master-slave process data transfer

Master

- The SL master can read and write into all of the channels of all of the slaves/transceiver.
  Configuring data:
  Function block @SL: MOD connection = 1...5
  For each slave: e.g. one SLSVAV

Slave

- Each slave can read all of the channels and write into a max. of 8 (**own!**) channels.
  Configuring data:
  Function block @SL: MOD connection= 0
  For each read channel: e.g. one SLAV
  For each write channel: e.g. one SLSV,
  Connection, FSL: Slave's **own** address
  Connection, NSL: 1

Slave-to-slave data transfer

- In order to transfer data from slaves/transceivers to slaves/transceivers which are physically located in front in the ring, in the same bus cycle, the slave-to-slave communications setting must be used.
  Configuring data:
  Function blocks SLAV and SLDIS: Connection QV = 1

3.17.3 Applications and modes which should be set

Various SL master, dispatcher and slave modes can be set by appropriately configuring SIMOLINK.

For **position-synchronous** actual value sensing and setpoint input (e.g. “virtual shaft” for printing or packaging machines), the **jitter-free** (equidistant in time) modes should be set

- External mode (Mode 4),
- Interrupt automatic mode (Mode 3) and
- External cyclic mode (Mode 5)
- Cyclic automatic mode (mode 10) and

(refer to the SIMOLINK function block description @SL).

Synchronized data send, 1 cycle deadtime

For the mode 3, 5 and 10, the telegram data of the previous bus cycle are processed in parallel to the bus cycle and equidistant SIMOLINK telegrams are sent and received. This allows the shortest SIMOLINK cycles to be configured. Ideally, this technique is suitable for applications with “**virtual shaft with values which uniformly change**”, which are required, for example, for printing machines.

The operating modes **automatic mode** (Mode 3) with processing in an interrupt task Ix should be used for jitter-free synchronization of the drives

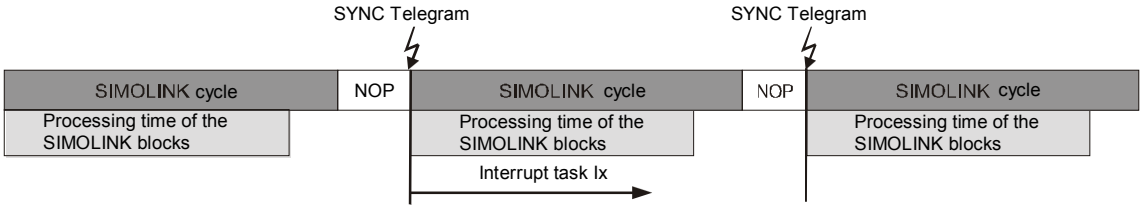

Fig. 3-53 Automatic mode (Mode 3)

and **external-cyclic mode** (Mode 5) with synchronization to the basic sampling time T0.

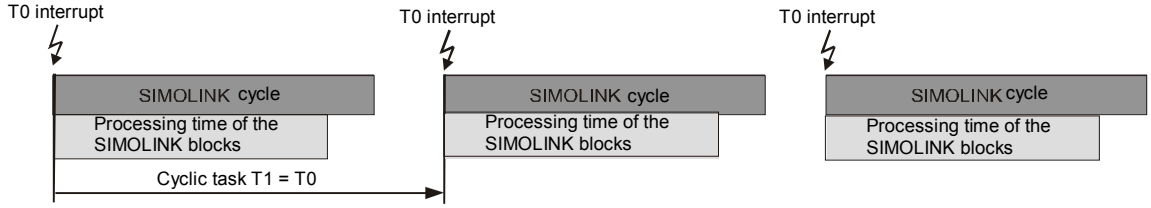

Fig. 3-54 External-cyclic mode (Mode 5)

The sampling time should be selected somewhat higher than the bus cycle time.

The external-cyclic mode offers the advantage that the processor hardware of two SIMOLINK rings can be synchronized to the (common) base sampling time T0.

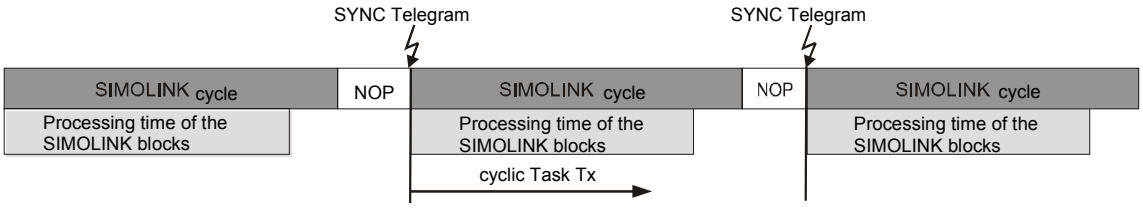

Bild 3-55 Cyclic automatik-mode (Mode 10)

The cyclic-automatic-mode 10 offers the advantage to place the function block configuration in cyklic tasks, in opposed to mode 3.

Fastest sensing, synchronous

The jitter-free SL-master mode, external-mode is best suited for synchronous actual value sensing with the fastest processing (minimum deadtime). This means, that it can be used as "**virtual shaft with dynamically changing values**", for example, for packaging machines.

In the **external mode** (Mode 4) the SIMOLINK cycle is synchronized to the base sampling time T0. The SIMOLINK blocks are immediately executed in the configured interrupt task Ix when the SYNC telegram is subsequently received.

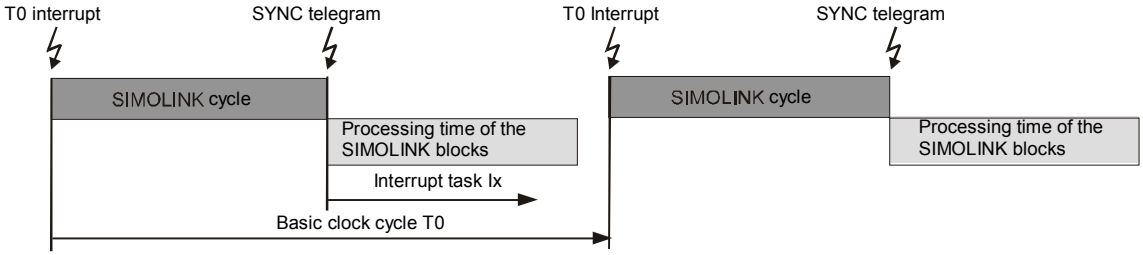

Fig. 3-56 External-mode (Mode 4)

The base sampling time T0 setting must correspond as a minimum to the bus cycle time plus the interrupt task processing time.

Fastest data send, non-synchronous

If data are to be transferred to other nodes after the calculation with minimum deadtime, then either the non-synchronous mode or the timer mode is used.

For the **non-synchronous mode** (Mode 1), data is directly output after the SIMOLINK blocks have been processed in a cyclic task Tx.

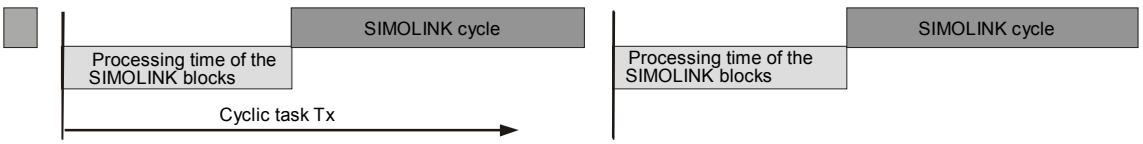

Fig. 3-57 Non-synchronous-mode (Mode 1)

In the **timer mode** (Mode 2), data is directly output after calculation in an interrupt task Ix which assigns the processing of the SIMOLINK blocks a higher priority.

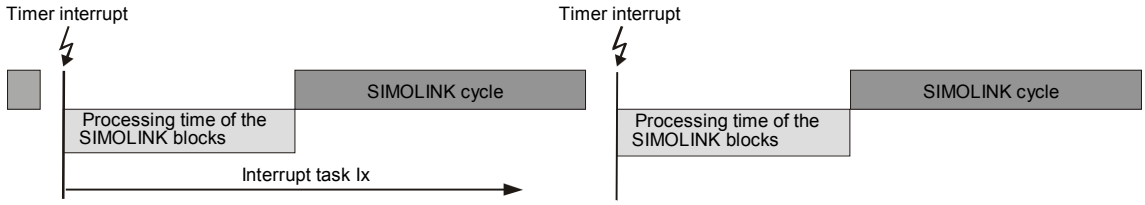

Fig. 3-58 Timer-mode (Mode 2)

In these non-synchronous SL-master modes, which exhibit jitter, the coupled drives cannot be operated with position synchronism if the SYNC telegram is sent in the time intervals which depend on the actual configuring. This allows the fastest possible data transfer between SL master (Mode 1 or 2) and the slave (Mode 0).

Reading telegrams, synchronous

The **slave mode** (Mode 0) is used to read and evaluate the bus data transfer in a drive ring, for e.g. monitoring and diagnostic purposes.

With each received SYNC telegram, the SIMOLINK module initiates that the configured interrupt task Ix is processed. If it is used as the receive section for fast data transfer between SL master and slave, all of the telegrams can be read and processed. Furthermore, it is possible to write a max. 8 telegrams, in order to, for example, transfer signals to the SL master.

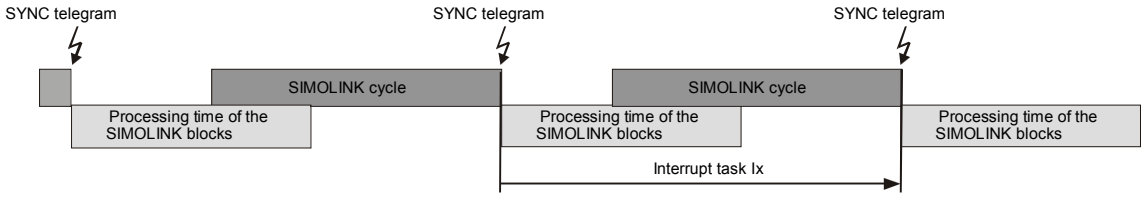

Fig. 3-59 Slave mode (Mode 0)

Coupling two automation systems

In order to send data between two automation systems via SIMOLINK, which exceeds the amount of data using 8 telegrams, two independent SIMOLINK rings are required. This means that every node can be configured once as SL master to send in one ring and as slave to receive in the other ring. This technique is used, for example, to achieve

- synchronized processing and
- extremely fast data transfer

between two SIMATIC FM 458 modules each with two EXM 448-1 expansion modules.

Cyclic or interrupt task ?

When selecting the operating mode, it should be noted, that interrupt task processing can interrupt cyclic tasks at any time. This can influence the timing. For the non-synchronous mode, the SIMOLINK cycle is delayed and for the external cyclic mode, T0 must be adapted to prevent computation time overflow or multiple sending of the same values which have not been re-calculated.

Synchronization to the base sampling time T0 can be set in 100 µs intervals while interrupt tasks are initiated by the SYNC telegram, dependent on the telegram duration.

3.17.4 Configuring - first steps

Using as an example a master-slave coupling, the necessary settings are subsequently described which must be or should be observed when configuring.

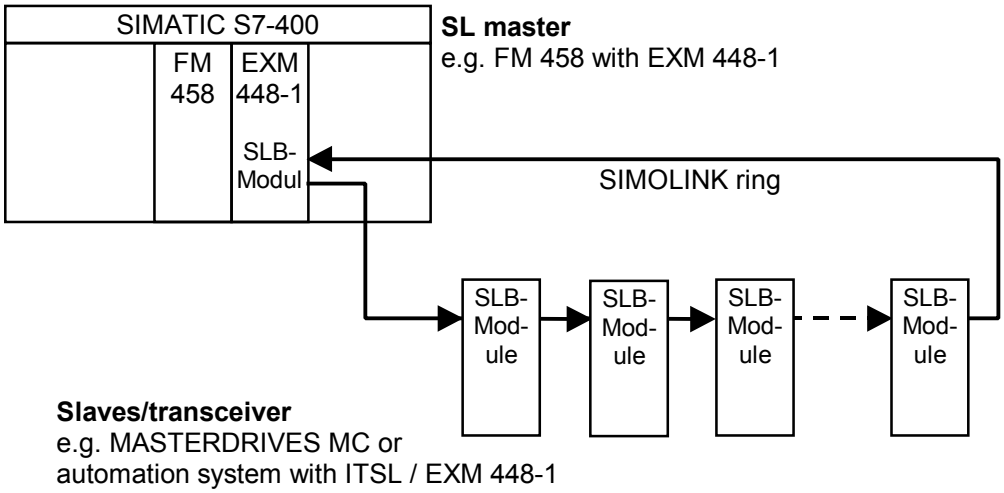

Fig. 3-60 Example for a master-slave coupling

Hardware

The SIMOLINK ring comprises the minimum of two and a maximum of 201 SLB modules, which are coupled to one another through fiber-optic cables. There is only one SL master on a ring. All of the other nodes are slaves.

An SLB module is a hardware component of an ITSL, an EXM 448-1 module or an option module SLB (**S**IMO**L**INK **B**oard, Order No. 6SX7010-0FJ00).

NOTE Additional information on these modules and their installation is provided in the User Manual D7-SYS “Hardware“, or SIMOVERT MASTERDRIVES Instruction Manual SLB SIMOLINK board.

3.17.4.1 Configuring the SIMOLINK coupling under STEP 7

For SIMATIC FM 458 with EXM 448-1, the basic clock cycle T0, possibly the interrupt task Ix and the symbolic hardware assignment for the SIMOLINK are set in the HW Config of STEP7 in the properties dialog box.

NOTE The EXM 448-1 expansion module should be configured as EXM 448 in HWConfig.

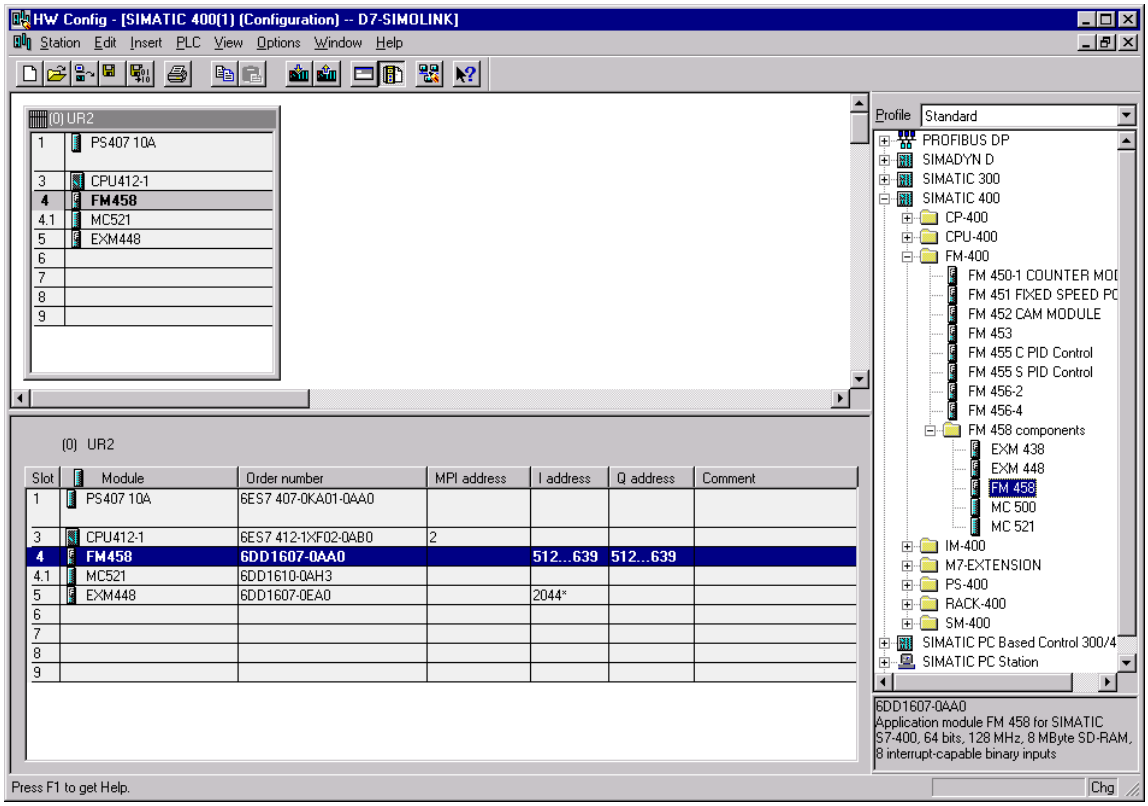

Fig. 3-61 Configuring for FM458 with EXM448-1

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Basic clock cycle

The basic clock cycle time must be set in HWConfig in the properties window under the "Basic clock cycle" tab.

The basic sampling time must match the PWM frequency set in the MASTERDRIVE MC (the factory setting is: 5 kHz, parameter P340). The time sectors are derived from this frequency.

The usual values are 3.2 ms, 1.6 ms and 0.8 ms, to which the system can be synchronized. 1.6 or 3.2 ms are set depending on the control type.

The value, set as the base sampling time, must also be entered in parameter P746 of the MASTERDRIVES MC.

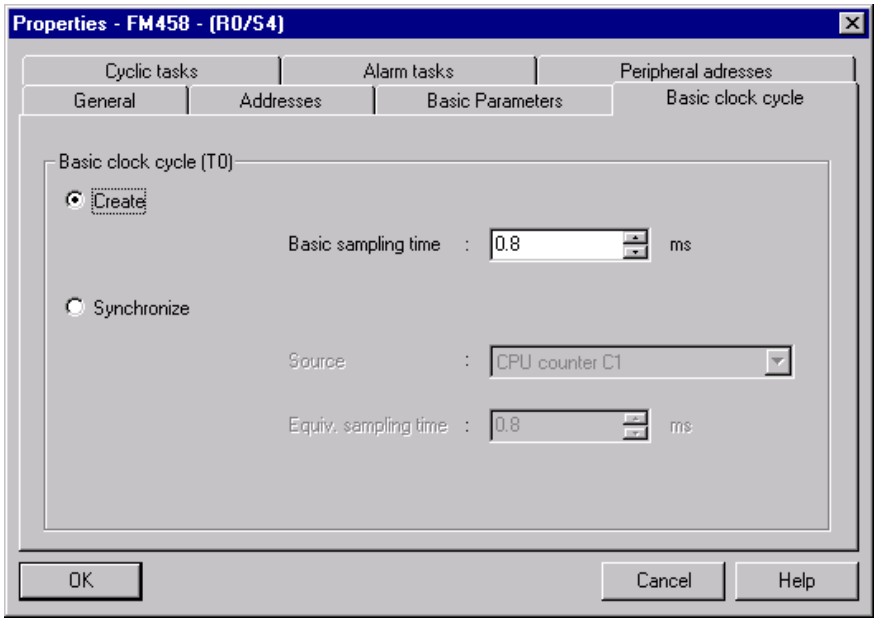

Fig. 3-62 Basic clock cycle in the HW Config

Interrupt task

For modes 0, 2, 3 and 4, sources must be assigned to initiate the configured interrupt tasks.

The settings are made in HW Config in the Properties window under the "Interrupt task" tab, dependent on the configured hardware components.

Mode	Interrupt source to be set for interrupt task Ix of the SIMOLINK blocks, if:			
	EXM 448-1/ITSL, 1st expansion	**EXM 448-1/ITSL, 2nd expansion**	**optional SLB module ITSL, 1st expansion**	**optional SLB module ITSL, 2nd expansion**
0	LE bus interrupt 1	LE bus interrupt 3	LE bus interrupt 2	LE bus interrupt 4
2	LE bus interrupt 5	LE bus interrupt 6	LE bus interrupt 7	LE bus interrupt 8
3	LE bus interrupt 1	LE bus interrupt 3	LE bus interrupt 2	LE bus interrupt 4
4	LE bus interrupt 1	LE bus interrupt 3	LE bus interrupt 2	LE bus interrupt 4

Table 3-62 Interrupt task source assignment for expansion modules with SIMOLINK

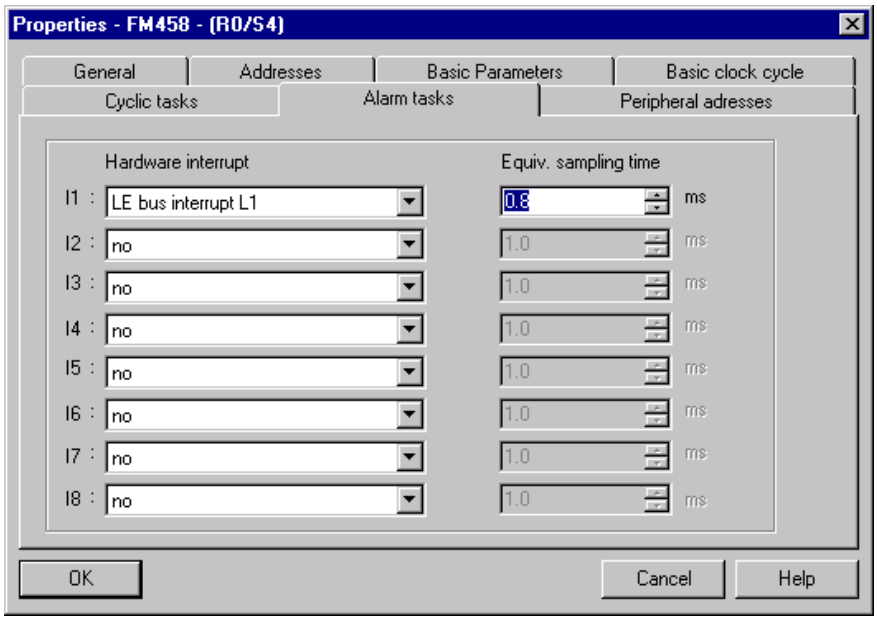

Fig. 3-63 Alarm task setting in the HW Config

Hardware addresses, SIMOLINK blocks

The SIMOLINK blocks @SL, SLAV, SLD, SLDIS, SLSV, SLSV2 and SLSVAV must be assigned to a HW address in the HW Config properties window of the EXM 448 under the "Plug-in module / I/O addresses tab.

The "process I/O" should be activated as plug-in module type. After this, symbolic names can be assigned for the I/O addresses (pre-set symbolic names are entered via the "Default" button.

The SIMOLINK blocks only use the symbolic name under “I/O address 2” (SIMOLINK does not require “I/O address 1”).

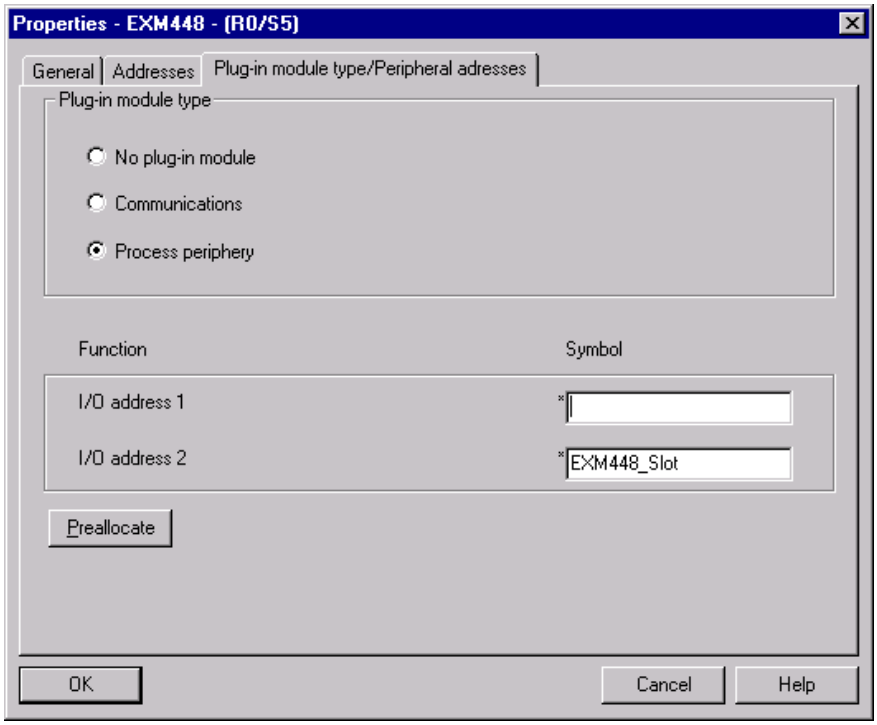

Fig. 3-64 Symbolic hardware assignment of an EXM 448-1

Different symbolic names are assigned for each SIMOLINK interface.

For example, when configuring an ITSL module, symbolic names are entered for the integrated (TAD) and the optional SIMOLINK interface (OAD) under the "Addresses" tab:

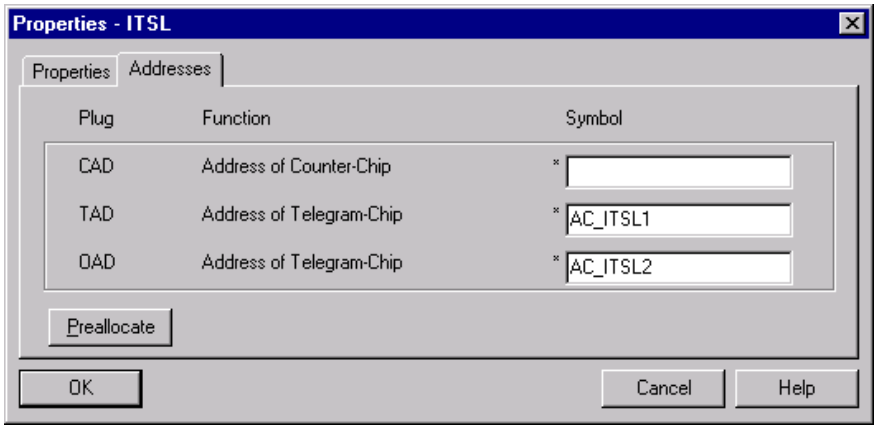

Fig. 3-65 Setting hardware addresses for an ITSL module with optional SLB module

3.17.4.2 SIMOLINK function blocks

The configuring engineer can use the following function blocks:

- @SL SIMOLINK central block
- SLAV SIMOLINK receive block, one for each actual value
- SLSV SIMOLINK send block, one for each setpoint
- SLSV2 SIMOLINK send block, for two setpoints
- SLSVAV SIMOLINK send and receive block for up to 8 setpoints and actual values of the slave
- SLD SIMOLINK delta evaluation
- SLDIS SIMOLINK dispatcher

The central block @SL permits the initialization and monitoring of communications in a SIMOLINK ring.

It may only be configured once for each SIMOLINK ring in a sampled cyclic task (T4 or T5) which is, as a minimum, 4x longer than the send and receive block.

If a transceiver no longer receives a telegram as a result of an interruption, then it automatically sends a special telegram, which evaluates the @SL function block. The address of the node is output at NDM, which first signals the fault.

NOTE Additional information regarding the mode of operation and the connections (I/O) of the specified blocks are provided in the online help of the CFC Editor and in the "Function block library" reference Manual".

3.17.4.3 Parameterizing the MASTERDRIVES MC

The following parameters must be set in the SIMOVERT MASTERDRIVES MC (refer to the User Documentation „MASTERDRIVES MC“):

Parameter	Significance/setting
P740	Own node address, transceiver/slaves: 1...200 (dispatcher=0)
P741	Telegram failure time, if the telegram fails, fault F056 is output. The usual values: > 3 x bus cycle time (refer to P746)
P742	Send power, dependent on the length of the fiber-optic cable
P743	Number of nodes in the SIMOLINK ring
P745	Number of channels (this is only relevant for the dispatcher)
P746	Bus cycle time (only relevant for the dispatcher)
P749	Read address, which is generated from the node address and the channel number, whereby the node address does not have to match its own node address (P740) Example: 2.0 = node address 2, channel number 0
P751	Send data, Index 1 = channel 1 (low word), Index 2 = channel 1 (high word), Index 3 = channel 2 (low word), etc.
P755	SIMOLINK configuration 0x100 should be entered for modes 4 and 5 so that synchronization is realized (this is valid from firmware release 1.4 for MASTERDRIVES MC)

Table 3-63 Parameters for MASTERDRIVES MC

SIMOLINK

P.-Nr.	Name		Ind	Indextext	Parameterwert	Dim
P740	SLB Teiln.Adr.	+	001	1.SLB	1	
P741	SLB Tlg.Ausz.				10	ms
P742	SLB Sendeleist.				3	
P743	SLB AnzahlTeiln.	+	001	1.SLB	5	
P744	Q.SYNC Auswahl	+	001		B0 Festbinektor 0	
P745	SLB Kanalanzahl	+	001	1.SLB	4	
P746	SLB Zykluszeit	+	001	1.SLB	3.20	ms
P747	Q.SLB Appl.Flags	+	001		B0 Festbinektor 0	
r748	SLB Diagnose	+	001	Anz. SYNC-Tlg	0	
P749	SLB Leseadresse	-	001		1.0	
			002		1.1	
			003		1.2	
			004		1.3	
			005		1.4	
			006		1.5	
			007		1.6	
			008		1.7	
r750	SLB Empf.daten	+	001		0x0	
P751	Q.SLB Sendedaten	+	001		K32 Zustandswort 1	
r752	SLB Sendedaten	+	001		0x0	
P753	Q.SyncZeitzähler				K0 Festkon. 0%	
P754	Max.sync.Zeitsch				0 Buszykluszeit	
P755	SIMOLINK Konfig.				0x100	

Fig. 3-66 Parameters for MASTERDRIVES MC (DriveMonitor, and SIMOVIS)

Number of nodes

When configuring the system, it should be noted that the number of nodes is restricted by the following factors:

- Pulse frequency set in MASTERDRIVES MC
  The sampling time for the time sector to be synchronized is obtained from this pulse frequency (parameter number P340).
- Data quantity to be transferred
  The number of telegrams which are to be sent along the SIMOLINK ring between the SL master and the slaves.

The following formula applies:

$$N = \left(\frac{P746 + 3.18181\,\mu s}{6.36\,\mu s} - 2 \right) * \frac{1}{P745}$$

- with P746=bus cycle time (this depends on the pulse frequency and the time sector to be synchronized)
- with P745=number of channels
- with 6.36 µs=telegram run time

Node tables

When the MASTERDRIVES MC pulse frequency is set to 5 kHz, for example, the following values are determined:

No. of channels	No. of nodes		
	0.8 ms (T2)	1.6 ms (T3)	3.2 ms (T4)
1	124	201	201
2	62	124	201
3	41	83	167
4	31	62	125
5	24	49	100
6	20	41	83
7	17	35	71
8	15	31	62

Table 3-64 Node table for various bus cycle times (drive converter/inverter time sectors in brackets)

3.17.5 Coupling diagnostics

LEDs

The user can use the 3 LEDs on the front of the SLB module to analyze the operating status.

Operating display

LED	Status	Diagnostics information
green	flashing	Error-free net data transfer via SIMOLINK
red	flashing	SLB module in operation
yellow	flashing	Data transfer with the information processor FM458 or PMx is OK

Table 3-65 Operating display, SLB module

Fault display

LED	Status	Diagnostics information
green	dark/ bright	No net data transfer via SIMOLINK: Bus cable not connected or defective, poor fiber-optic cable transition, send power (launch power) too low
red	dark/ bright	SLB module power supply failed Replace the SLB module or power supply through FM458 and check PMx
yellow	dark/ bright	No data transfer with the automation processor FM458 or PMx, bus cable not connected or defective, poor fiber-optic cable transition, send power (launch power) too low, replace SLB module or automation processor FM458 and PMx

Table 3-66 Fault display, SLB module

Fault output

The fault statuses are output coded at the outputs YF of the appropriate SIMOLINK blocks.

NOTE Only the last fault event is displayed.

Value	Diagnostics information **F:** Fault cause **R:** System response **A:** Remedy
2	F: TAD input is incorrectly connected (e.g. HW address of CS8+SLB module) R: No telegram data transfer A: Use symbolic hardware assignment of the EXM 448-1 or ITSL module
3	F: Incorrect module or SLB module not inserted or defective hardware R: No telegram data transfer A: Use or replace SLB module
4	F: SLB module is already being used by another central block @SL, configured twice R: No telegram data transfer A: Only use one FB @SL for each SIMOLINK ring

Value	Diagnostics information **F:** Fault cause **R:** System response **A:** Remedy
5	F: Memory access problem (internal error message) R: No telegram data transfer A: Reduce the size of the application software or move to another process module
6	F: Send/receive block(s) signal: Central block @SL not configured R: No telegram data transfer A: Insert @SL in the software (min. 4 x sampling time of send/receive blocks)
9	F: This software does not support this hardware combination, e.g. CS8+SLB module R: No telegram data transfer A: Use an EXM 448-1 or ITSL module for the drive coupling
10	F: Modes 0, 2 and 4: Block was not configured in an interrupt task R: No telegram data transfer A: Configure the appropriate block in the interrupt task
11	F: Modes 1 and 3: Block was not configured in a cyclic task R: No telegram data transfer A: Configure the appropriate block in a cycle task
12	F: Mode 5: Block was not configured in a cyclic task with T1=T0 R: No telegram data transfer A: In HW Config: Select T1=T0, configure the appropriate block in cyclic task T1
13	F: Mode 4: Equivalent sampling time is not equal to T0 R: No telegram data transfer A: In HW Config: Select an equivalent sampling time = T0
14	F: Modes 0, 2 and 4: Interrupt source for the interrupt task is incorrect R: No telegram data transfer A: In HW Config: Set the interrupt task source as in the assignment table
15	F: Mode 1: Not all send/receive blocks in one sampling time R: No telegram data transfer A: Configure all of the send/receive blocks in the same sampling time
16	F: Incorrect mode setting R: No telegram data transfer A: Set a valid mode (mode 0...5) at FB @SL
17	F: Mode 0, FB @SL: incorrect node address (slave) at input ASL R: No telegram data transfer A: Select a valid setting at input ASL: 1...200
18	F: FB @SL signals: No send and receive blocks available R: No telegram data transfer A: Configure send and/or receive block(s)
19	F: No. of SIMOLINK telegrams too high or SIMOLINK cycle time exceeded R: Telegram data transfer up to max. possible number A: Configure max. 1021 net telegrams or increase SIMOLINK cycle time or configure fewer SIMOLINK blocks (refer to the formula)
20	F: Send/receive block signals: Incorrect slave address R: Restricted telegram data transfer functions A: Select valid slave address: 0...200
21	F: Send/receive block signals: Channel number incorrect R: Restricted telegram data transfer functions A: Select a valid channel number: 0...7

Value	Diagnostics information **F:** Fault cause **R:** System response **A:** Remedy
22	F: Mode 0: Slave attempts to write into an incorrect address R: Restricted telegram data transfer functions A: Select own slave address
23	F: Logical configuring error: Slave-to-slave communications was configured as duplex operation, however, only one direction is possible for each slave (send or receive) R: Send and receive the same data A: Either configure send or receive for slave-to-slave communications
30	F: Physical data transfer faulted on the SIMOLINK ring R: No telegram data transfer A: Increase send power (launch power) at one of the subsections, replace medium or connector
31	F: CRC error (check sum error), data transfer along the ring faulted R: Telegram failure A: Increase send power (launch power) at one of the subsections, replace medium or connector
32	F: Timeout error in the SIMOLINK ring, bus node signals a fault R: No telegram data transfer A: FB @SL, evaluates output NDM, beforehand, check node and medium
33	F: Mode 0: Signaled SIMOLINK cycle time (in the special telegram from SL master) does not correspond to the configured equivalent sampling time R: Restricted telegram data transfer functions A: In the HW Config: Adapt the equivalent sampling time of the slave to that of the SL master

Table 3-67 Error output, SIMOLINK-FBs

3.17.6 Options and accessories

The following are available to configure a SIMOLINK coupling and as spare part:

Order No.	Components
6SE7090-0XX84-0FJ0	SLB module, spare part (without documentation, without connector)
6SX7010-0FJ00	SLB module, retrofit package (documentation, 2 fiber-optic cable connectors, 5m plastic opto-cable, 1 connector for terminal X470)
6SY7000-0AD15	Attachment for SLB (2 LWL cables, 5m plastic opto-cable)
6SX7010-0FJ50	System package for SLB (40 fiber-optic cable connectors, 100m plastic opto-cable, 20 connectors for terminal X470)

Table 3-68 SIMOLINK option modules and accessories